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Rochester Institute of Technology

A Thesis submitted to the Faculty of the
College of Imaging Arts and Sciences
in candidacy for the degree of
Master of Fine Arts

Blooming Numbers:
Interactive Visualization in Cultural Contexts Based on Numbers

by Yuri Lee

June 07, 2006

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Blooming Numbers

Interactive Visualization in Cultural Contexts Based on Numbers

Abstract

The Blooming Numbers is an application based on the web for the purpose of visualizing the relationships between cultural contexts and the preference of numbers in interactive and dynamic ways. People from different cultural background have varying opinions about numbers. My basic idea was to explore effective visualization based on this interesting observation. My thesis project provides an interactive application to convey a huge amount of information about numbers, as well as a fun experience with an art work generated with diverse data provided by the users.

Thesis Website

Thesis Project *http://www.urielee.com*
Thesis Documentation *http://www.urielee.com/paper/*

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1. Introduction

1.1. Motivation

1.1.1. Information Visualization

When I went to the FITC in 2004, I was deeply impressed with a presentation by Japanese designers. It was a short presentation between main presentations, but it gave me fresh incentive to rethink my ideas on interaction design. The work was a visualization using real-time data obtained from the elevators of the Dentsu headquarters placed in Tokyo. Dentsu is a Japanese advertising agency and its headquarters has 35 elevators. The designers used the elevators as a design concept to represent the advertising agency itself. The information collected from elevators contains the data of ascents, descents, stop, and which floors they are on. This data of all elevators in the building was visualized in various and entertaining ways in real-time; for example, people's faces smile when the elevator is going up and frown when the elevator is going down. I was fascinated by the fact that simple numbers became a meaningful design work through visualization. We are overwhelmed with information, but our ability to get information is limited and most raw information that cannot become meaningful knowledge is easily ignored. Also the complexity of information is increasing and information keeps changing with the changing world. Thus, static visualization designs such as diagrams or maps are not enough to convey dynamic information. A new kind of interactive visualization is needed to transform a huge amount of complex information into meaningful knowledge. As an interaction designer, this area merits study in order to keep pace with the digital era.

1.1.2. Numbers

After deciding to explore the field of information visualization, I looked for suitable information that has large quantity of continuously changing data. In addition, the information should be interesting and useful. It spent a lot of time finding a subject. I took note of all information I encountered in my daily life. While reading the book, Information Visualization, I learned that there are two types of informa-

tion: sensory representation and arbitrary representation. Sensory information is understood without training and across cultural boundaries, and resistant to instructional bias. In contrast, arbitrary information is hard to learn, easy to forget, embedded in culture and applications, formally powerful and capable of rapid change. An Arabic numeral is an example of arbitrary information. Numerals do not exist in the real world, and they were invented as a symbol system centuries ago. Thus, we learned numbers when we were young and now we use numbers without any hesitation. Living without numbers is inconceivable. At this point, I came up with interesting thoughts. Even though numbers are universal symbols, people's opinions about numbers are based on their cultural context. I can find good illustrations because I am studying with international students in a foreign country. In my native Korea the number 7 is the luckiest and the number 4 is the unluckiest. However, in Western culture, the number 7 is lucky, but the number 13 is not. But these differences are not limited only to nations. Each person has his or her own lucky and unlucky numbers. When I imagined the data of both people's preferences about numbers and the connections with their personal backgrounds, the amount of information is enormous and the complexity of the connections is also huge. Thus, I determined to challenge the visualization of people's cultural contexts based on their preferences about numbers.

1.2. Defining the problem

Where is the boundary of the data?

This data of preferences about numbers was not an existing data. That's why I could not predict the result of the visualization, and had to consider all possibilities of design. In addition, the range of numbers and the variety of cultural contexts are infinite, so I had to narrow the possibilities.

How can I convey the feeling of numbers in visual form?

A number is a universal symbol not a visible object, so I was concerned about using the design aspect to express the concept of numbers. Another concern was how to show users' preferences and their cultural backgrounds. If a user chooses a favorite and least favorite number, these numbers should be changed to represent the user's preferences. Thus, users should easily recognize which numbers are popular in a particular background or which numbers are unpopular.

How can I build the technical part?

This kind of information visualization needs a lot of programming knowledge. Because mapping data is originally part of the science of statistics; furthermore, this visualization of data has to interact with users. When researching this area, I discovered that most people who designed the dynamic information visualization had degrees in computer science or information technology. But visualization is more than programming. Thus, an aesthetic ability is required to arrange and communicate the complex and abundance of information more effectively. However, not many people have both programming skills and visual design abilities. In my case, I have studied design area for more than six years, so I am confident in my ability to communicate visually. Even though I was interested in learning programming skills and focused on hard coding, the technical ability cannot be distinguished from programming ability. Accordingly, I tried to develop an idea of both transmitting information with ease and creating a fine visual appearance while building the system to connect a data server and Flash in real time.

What does the user desire to learn from this visualization?

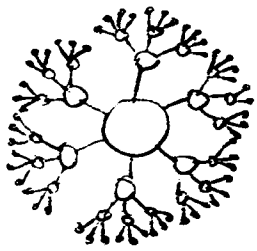
The purpose of the visualization is to communicate information to users in effective ways. When designing the information visualization, I had to consider users who need the information and who will use the application. The target users of this project are people who are interested in numbers and cultural differences, as well as who enjoy playing with flash actionscript, programmatic art works, and dynamic information visualization. I need to research these people and know their specific needs pertaining to visualization.

2. Research

2.1. Case Study: Visual Structures in Information Visualization

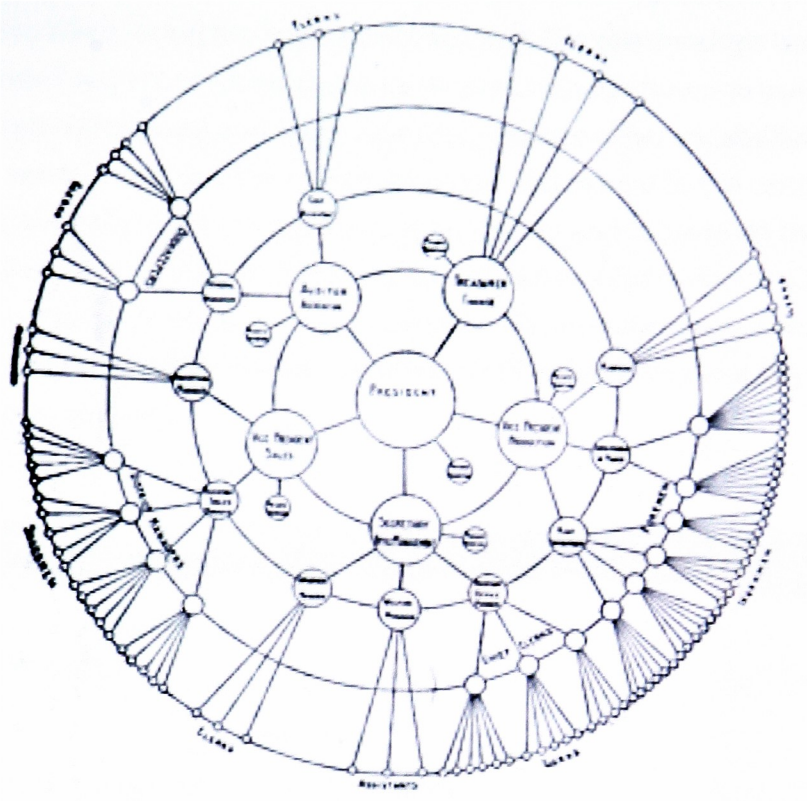
I researched examples of information visualization, and found some patterns of visual structures. Thus, I classified visual structure according to four standard types: hyperbolic, tree, organic and random. There are other works not included in these categories, and other works have two types or three types of visual structure; however, the patterns I choose are used in many examples, and knowing these types of structures is useful in designing information visualization. After grouping examples into four structures, I found that each structure has its own characteristics and it is matched with a different type of information. In this section, I will explain the characteristics of visual structures and provide examples.

2.1.1. Hyperbolic Structure

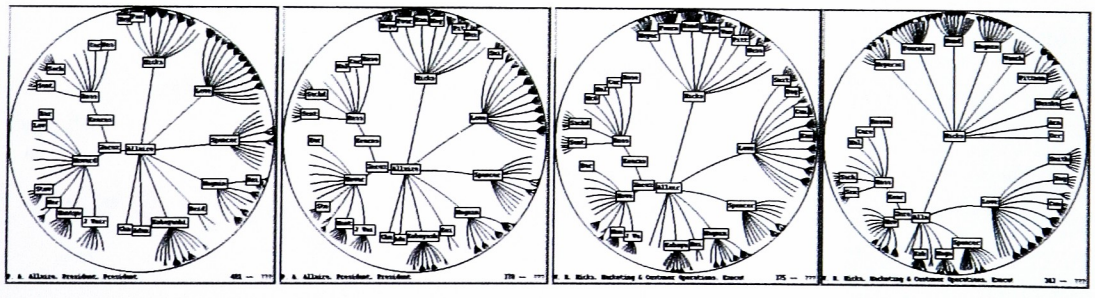


Hyperbolic Geometry is geometry of Einstein's General Theory of Relativity and Curved Hyperspace. The paper, "A Focus+Context Technique Based on Hyperbolic Geometry for Visualizing Large Hierarchies" in the CHI 95 Proceedings papers, introduced the hyperbolic structure. The authors, John Lamping, Ramana Rao, and Peter Pirolli, stated "Our technique assigns more display space to a portion of the hierarchy while still embedding it in the context of the entire hierarchy. The essence of this scheme is to lay out the hierarchy in a uniform way on a hyperbolic plane and map this plane onto a circular display region. This supports a smooth blending between focus and context, as well as continuous redirection of the focus." The advantage is that this structure can handle a large amount of information in a small space because of the fisheye distortion and show the hierarchy while

navigating information. It is essential part of visualization to keep the user exploring the hierarchy without getting lost. The first goal of information visualization is to help users find what they need within tangled large information. Also it is good for changing focus.



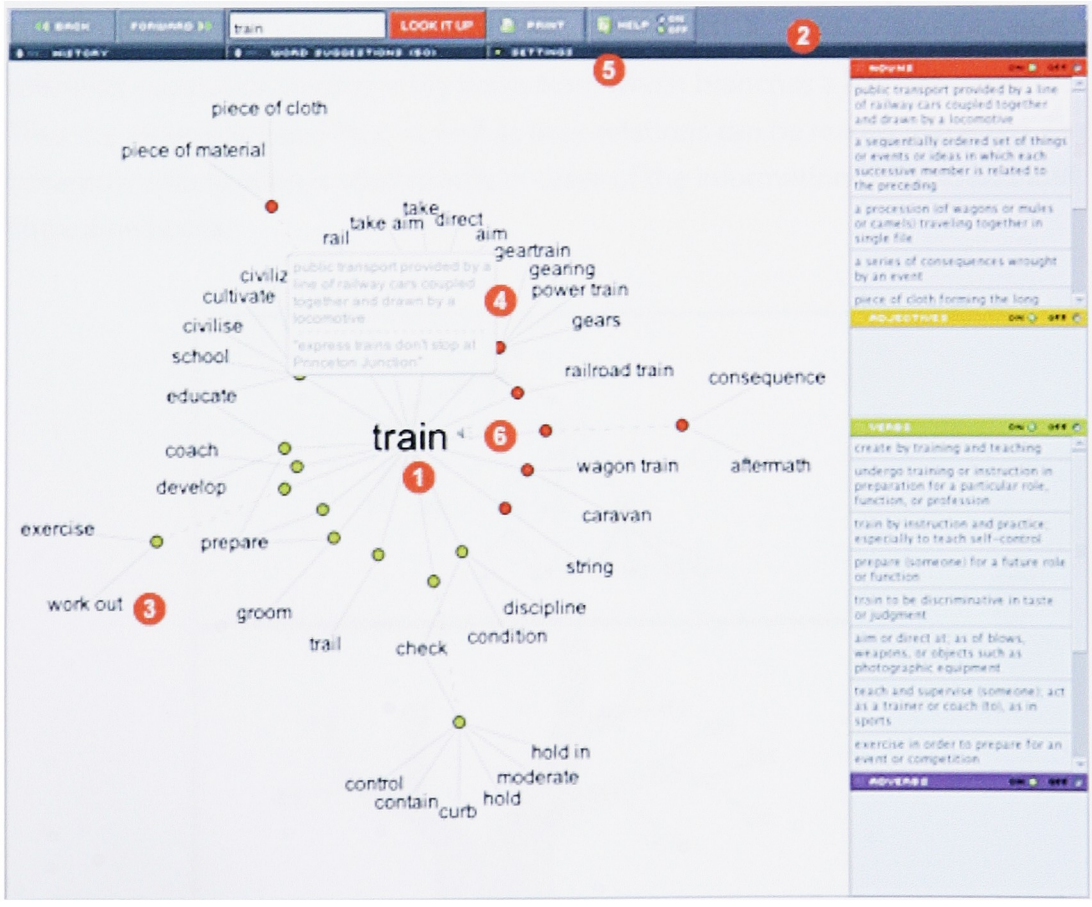
2.1.1.1. Radial form of Organization Chart by Alexander Hamilton Institute



2.1.1.2. Changing the focus in hyperbolic geometry

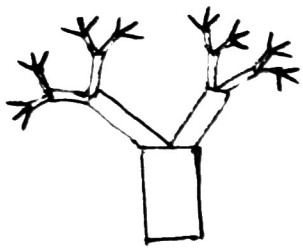
Visual Thesaurus

This Visual Thesaurus was a software program developed by Thinkmap.inc in 1998. It is an interactive dictionary and thesaurus that support exploration and learning vocabulary. When a user searches a word, other words and related meanings are visualized, using the hyperbolic structure. The relationships between a selected word and other words and meanings are clearly shown to users, so users can understand the word and more intuitively explore other vocabularies. When the other word is selected, the word is enlarged and moved to the center, other words are shrunk and the connection is regenerated and focused on the word. This transition shows how the focus moves without any confusion. The hyperbolic structure is especially useful for this vocabulary visualization because it is important to know the semantic hierarchies of words in order to improve the efficiency of learning vocabulary.

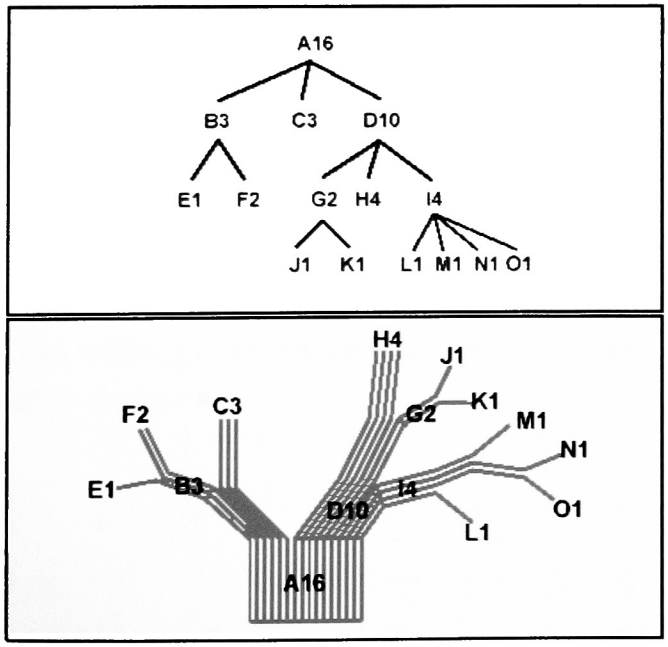


2.1.1.3. Visual Treasure by Thinkmap.inc

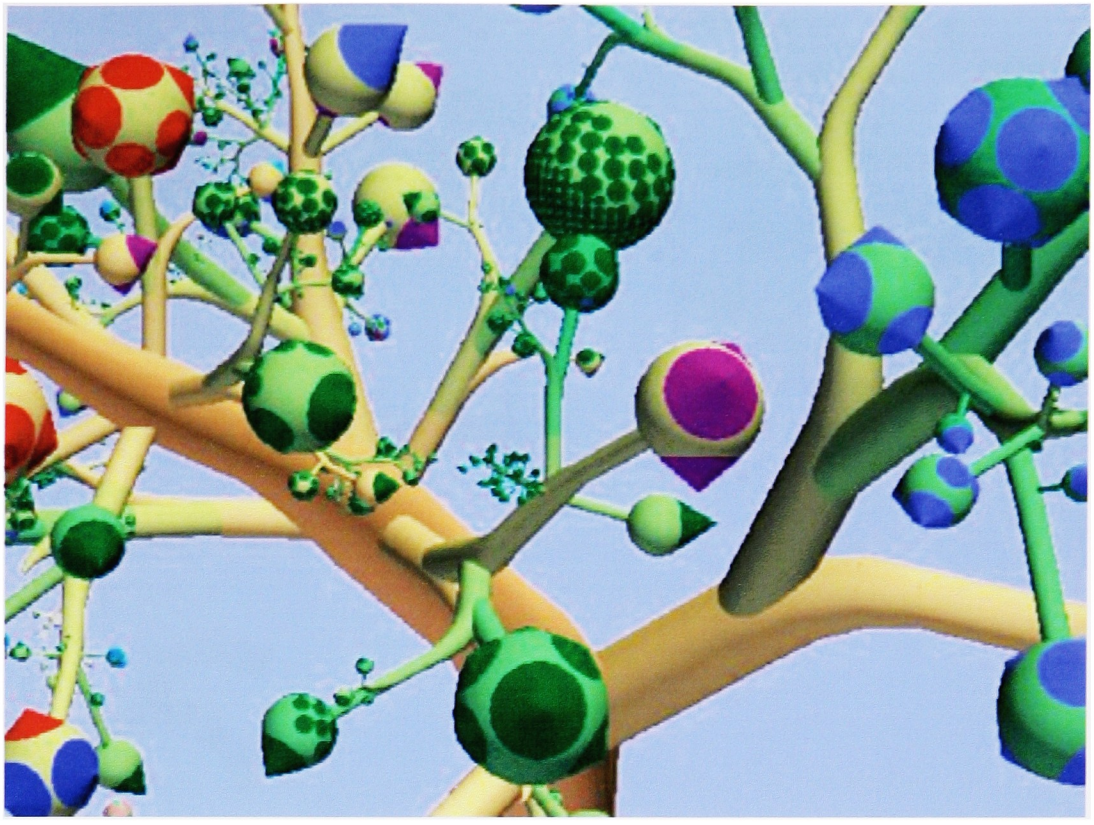
2.1.2. Tree Structure



The tree structure was presented by Ernst Kleiberg, Huub van de Wetering, Jarke J. van Wijk in the paper "Botanical Visualization of Huge Hierarchies" in 2001. The tree structure is based on the simple botanical tree, consisting of branches, leaves, fruit and branches. The method the authors described in the paper is that branches are emphasized, long branches are contracted, and sets of leaves are shown as fruits. This method is excellent for visualizing huge hierarchy structures. When we show the directory structure, we usually draw the node and link diagram. However, as it is represented using tree structure, the hierarchy is clearer because a tree is a familiar metaphor. People easily know from which branches a leaf has come. Thereby, directories and files, as well as their relations can be readily extracted. The botanical visualization is used mostly in cases of the information-rich content and large directories.



2.1.2.1. Node and link diagram and corresponding strands model



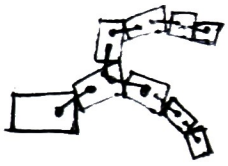
2.1.2.2. Final Model in the Botanical Visualization.

Ecotonoha

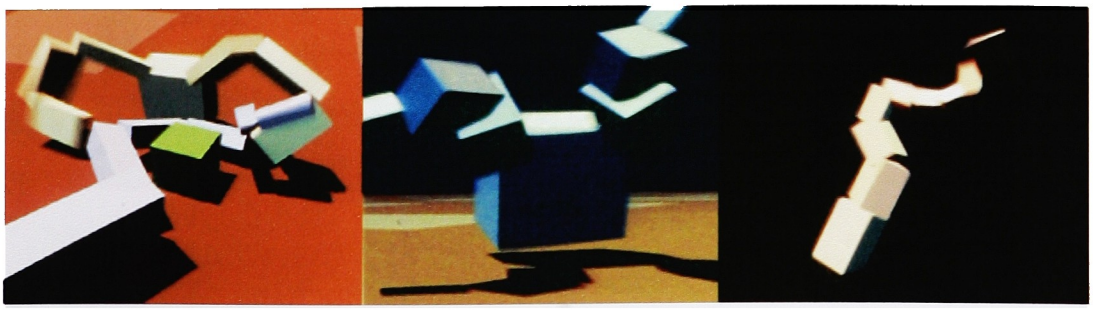
Ecotonoha is a project designed by Yugo Nakamura to nurture a virtual tree collaboratively, and at the same time contribute to the actual environment to cope with global warming. When people leave a message, a new leaf buds on the end of branches, and the virtual tree grows. And as Ecotonoha grows, real trees will be planted by a company, NEC. This tree structure shows both bunches of people's messages and the time sequences of making messages in an aesthetically impressive and perceptive way. We can easily tell which messages have already been left. However, as the tree grows, smaller overlapping offshoots appear on a branch. To solve this problem, on this virtual tree each branch has a function, and the color of selected message is changed.

2.1.2.3. Ecotonoha by Yugo Nakamura

2.1.3.Organic structure



The organic structure has simulated organic properties. In the past, it was often tested that the artificial objects simulate organic creatures in computer space. The most famous example is the Evolved Virtual Creatures, which was designed by Karl Sims in 1994. The video shows results from a research project involving simulated Darwinian evolutions of virtual block creatures. A population of several hundred creatures is created within a supercomputer, and each creature is tested for its ability to perform a given task, such as the ability to swim in a simulated water environment. The creatures shown are results from many independent simulations in which they were selected for swimming, walking, jumping, following, and competing for control of a green cube. The organic structure has the advantage of showing the progress of information whose structure and content are continually changing.

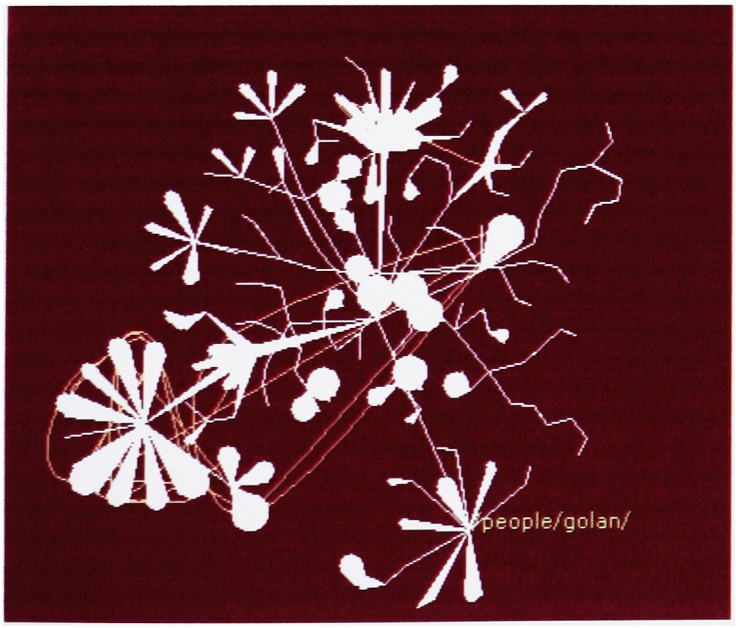


2.1.3.1.Competeing, hopping, and swimming creatures

Anemone

Anemone is a project that uses the process of "organic information design," the subject of a Master of Science in Media Arts and Sciences by Ben Fry in the Massachusetts Institute of Technology. The project visualizes the changing structure of a web site, juxtaposed with usage information employing simulated organic properties in an interactive, visually refined environment. In the paper, "Organic Informatin Design", the author, Ben Fry, stated:

> *Rules for growth can govern the creation of new branches of structure within the site. Atrophy rules decay unused areas, eventually removing them. Individual web pages can call attention to themselves as they are visited more rapidly than others. Individual branches grow based on input from the data. As the Preprocessor Engine reads the usage log, a reproduction rule causes branches to grow whenever parts of the site are visited for the first time. This avoids the problem of having to keep track of what pages are added to or re moved from the site. Using the usage data to create an implicit model of structure is a common theme in Organic Information Design. To balance growth is the notion of 'atrophy'. Branches associated with areas of the site that have not been visited will slowly whither away, causing them to visually thin out. Eventually the branches die, and are removed from the system.*



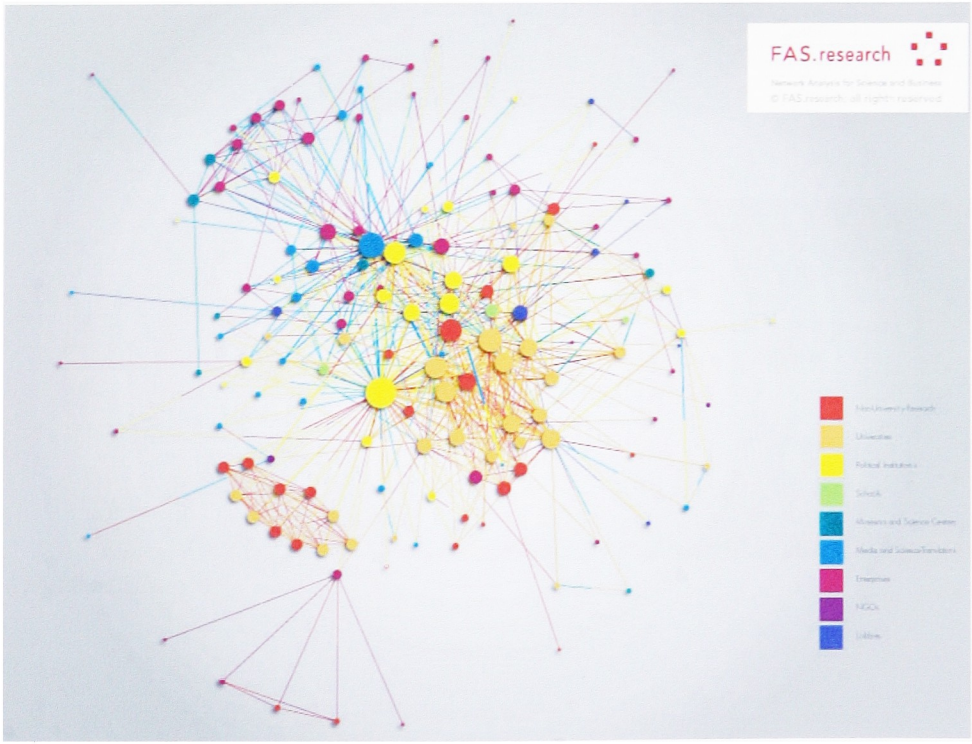
2.1.3.2.Anemone by Ben Fry

2.2.4.Random structure

I defined other visual structures, not having special characteristics like the previously mentioned structures, as random structures. Random structures are largely used in visualization. The data, which doesn't have specific hierarchy, can be visualized using the random structure. Because the data is positioned randomly, users can experience an unexpected visual result and the result can be a refined visual work. This structure is effective for showing the relationships of large amounts of information.

Public Understanding of Science

The FAS.research is a research institution located in Vienna, Austria, which has been producing great work in network analysis for science and business. This visualization illustrates one of their several network analyses. Various institutions (circles) are engaged in joint activities, which promote the public understanding of science and technology. The participating institutions are members of various color coded fields: Enterprises (purple), schools (light green), lobbies (blue), universities (orange), political organizations (yellow), museums (teal), media (turquoise), non-university research (red), non-governmental organizations (dark plum).



2.1.4.1.A map of network analysis by the FAS research

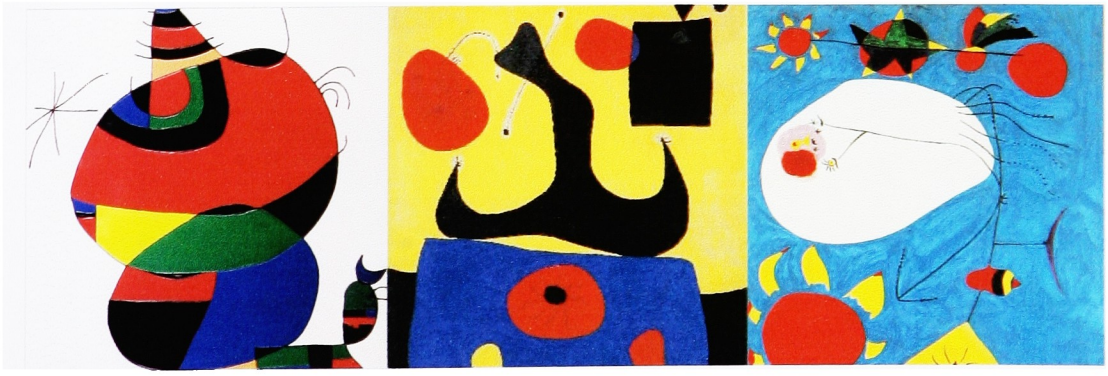
2.2. Aesthetics Inspiration for Visualization Design

In the process of ideation, several areas inspired me to design the information visualization in an aesthetic view. The information visualization has essential meanings of not only communicating data to users, but also giving the aesthetic satisfaction of visual graphics. Thus, users enjoy the refined visual graphics made by complex data through high technology in visualization.

2.2.1. Fine Arts

In information visualization, objects are used to show large amounts of information more effectively. Thus, I drew upon the fine arts to find ideas about the composition of objects. The paintings of famous modern artists, Kandinski and Miro, were especially helpful.

2.2.1.1.Paintings of Kandinski

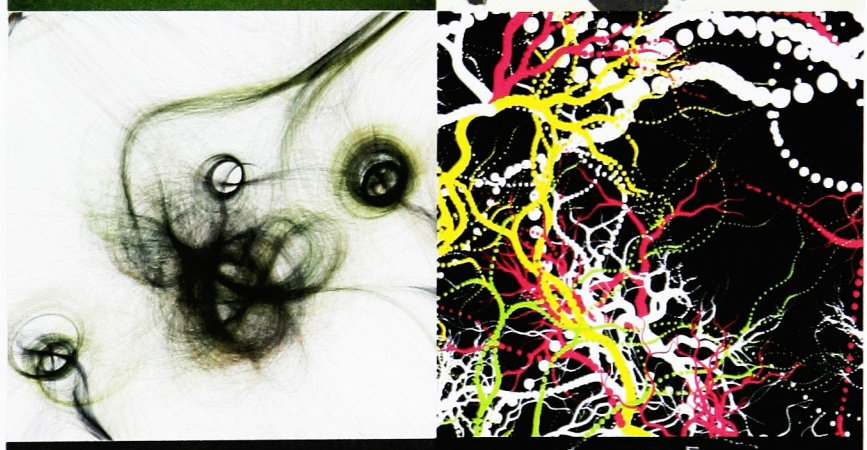


2.2.1.2.Paintings of Miro

2.2.2.Programmatic Arts

Nowadays, artworks generated with programming are famous in computer space. Artists in this area use programming platforms such as Macromedia Flash Actionscript, Processing and Java. Many programmers and designers experiment with creative modes of visual interaction. The information visualization is close to this area because data is dynamically visualized in the same way, with advanced programming. Therefore, these programmatic arts are useful for inspiring visualization design.

2.2.2.1.Vattenfall media facade by ART+COM (left), Once upon a forest by Joshua Davis(right)



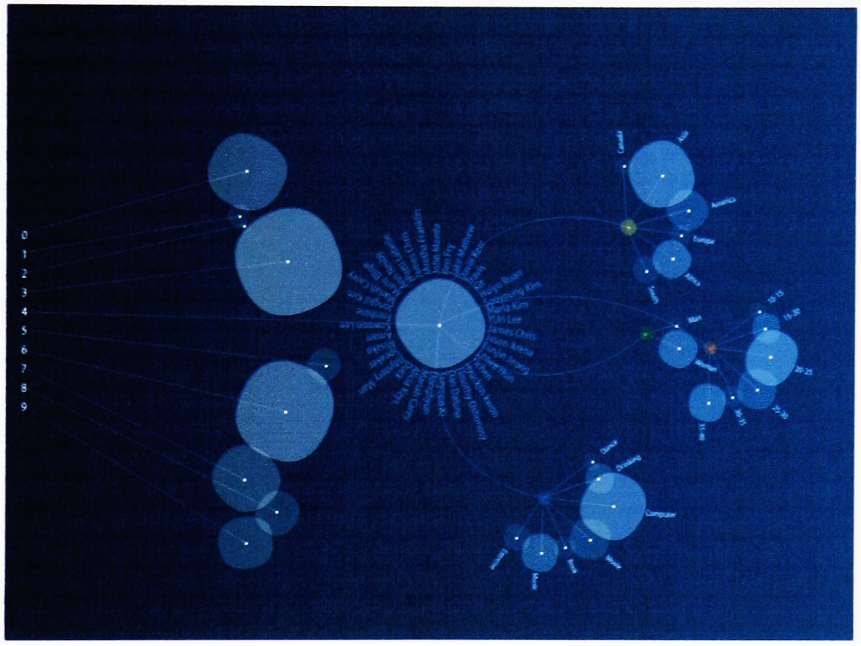
2.2.2.2.Tissue print by Casey Reas(left), Neon Organic by Marius Watz (right)

2.2.2.3.ElectroPlastique ElectroPlastique by Marius Watz(left), Clocksphere by Yugo Nakamura(right)

3. Process

3.1. Prototype 01

First idea was the visualization of the preferences of ten numbers and their cultural contexts. The user makes a sequence of ten numbers from 0 to 9, and inputs personal information such as nationality, gender and age. After the input, the data is visualized. I tried to visualize the data from the perspective of the user because the user has a strong interest in the information.

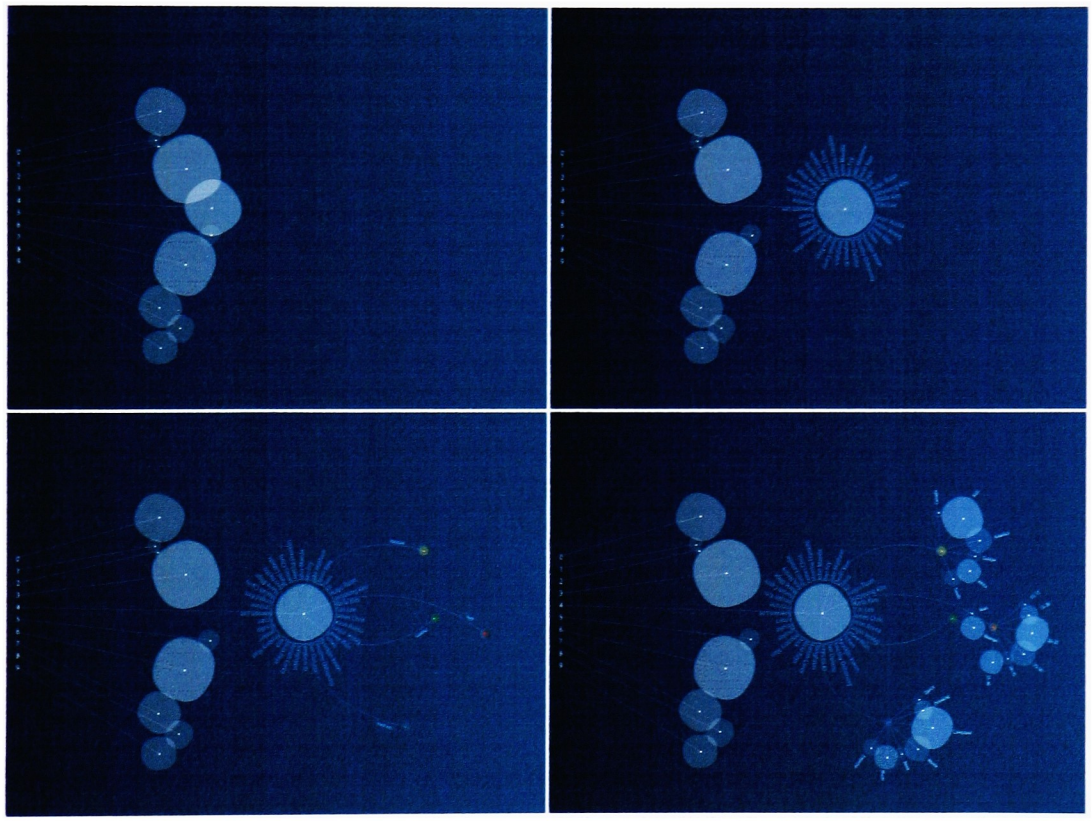


3.1.1..Prototype 01 Screenshot

3.1.1. Interaction Design

The concept of interaction is to present the information a step at a time. First, ten circles corresponding to with ten numbers are shown on the screen. The size and the alpha value of the circle are generated according to the order of preference so that users can recognize it visually. When the user clicks one circle, the second piece of information is visualized. Around the circle are the names of people who have chosen the same number. Four small circles grow from the center of selected circle. These small circles represent four sections of the user's sub information. Each small circle is different color for labeling categories. When the user clicks one small circle, other circles radiate from its center. Other circles represent the

information of background of people shown around the circle. These circles also have different sizes and alpha values in proportion to the number of people who are included in the sub category. For instance, in the continent category, there are six circles, representing the six continents. If the number of people from Asia is the largest among people who choose the same number, the circle of Asia is the biggest and the most alphas in circles connected with the continent circle. In this way, a user can understand the tendency of people to have similar preferences about numbers. To move the other people's data, a user can click a name placed around the circle. If one name is selected, the information of selected person is re-visualized from the first step.



3.1.2..The progress of interaction

3.1.2. Visual Design

The main visual component is a circle that is drawn freehand, not perfectly. I came up with this shape through the observation of cell. The reason is that circles contain a person's information just as his or her genes do. Moreover, this shape is good for expressing the acquisition or loss of information. The advantage of this visualization is that a user can obtain more detailed information only from interaction with the user. In this point, I imagined some mysterious organic object that is

growing or decaying according to the user's clicks.

I used only circles and lines to keep the design simple. The color is simply white color with some point colors. Because it contains a lot of information, other additional design components can interfere with the transmission of information. Some point colors were selected to classify categories.

3.1.3. Problems

- *Numbers should be more focused.*
  In this visualization, only small numbers are placed on the left. This is the visualization of numbers, so design, which can emphasize the concept of numbers, is needed.
- *The space in which people' names are placed is limited.*
  If the number of people increased, the space will be crowded with a lot of names and the readability will be compromised. I have to find a solution to accommodate a large number of people.
- *Hard to compare ten numbers.*
  In this visualization, a user cannot compare the people and people's information included in ten numbers.
- *Color-coding in different categories is weak.*
  The area of color-coding is too small to recognize. There should be more color in other parts to classify different sections.

3.2. Prototype 02

The second prototype was based on how to emphasize the concept of numbers. Therefore, I placed numbers in the center of screen, and increased the size of numbers to attract the user's gaze. In this visualization, the metaphor was trees on a small planet like that Antoine de Saint-Exupery's novel, The Little Prince." Inside the planet, user's data is shown, and other people's data is visualized outside the planet. It provides the user-centered visualization, so each user can have a different result of data mapping.

3.2.1. Interaction Design

The main interaction key is the rotation of a wheel of mouse. There is a circle of ten numbers in the center. The numbers are placed clockwise and have different alpha values according to the user's preference. This ring of numbers is rotated by the wheel of the mouse. While rotating the ring, the numbers are blurred in order to make user feel the rotation. At the same time, the data which is visualized in the stage is changed to follow the color sections placed outside the ring of numbers. The color sections are made of four visual categories: continent, age, gender, and color, which is the users' background information. The user can change the criteria of visualization and experience different visual results according to different contexts. The sections are classified using the color-coding. The author of Information Visualization said that color is useful for labeling information. Unique hues, including red, green, yellow, blue, white, and black, are natural choices when a small set of color codes is required. Thus, there are ten sections divided in one circle and those sections have four colors: red, yellow, green and blue. The area of visualization also has the same color codes with the section, so it is readily distinguished from other sections.

3.2.2. Function Features

Number Dial
Numbers are placed clock-wise direction according to the user's preference. The alpha values of each number also vary according to preference property. The user can rotate this number dial with a mouse-wheel. When rotating, the numbers will blur.

Properties Ring

There are four properties: nationality, age, gender, and color. The position of this property ring is fixed in the center. Thus, when the number dial is rotated, user can see different properties of each number according to the angle of rotation. When the dial is rotating, the angle is snapped in ten sections.

People

This dot represents people. Thus, a user can see how many people are in each section. The positions of dots are generated randomly in the circle. These circles have the same color according to properties' color coding. The size of the circle is generated by the percentage of people. Also a user can drag and drop these circles.

Selected Dot

Selected Dot is changed to red color and enlarged. The information of a selected person is shown next to the dot. The simple information contains an email address and numerical data. More specific information of the selected person can appear in an additional small window. Other dots for the same person are connected with curved lines.

Visual Controller

The User can change visual graphics using this controller. There are five options: people, text, circle, line, and percentage. The user can turn these options on/off to see what he or she wants to know. This controller allows the user to use the user-centered interface.

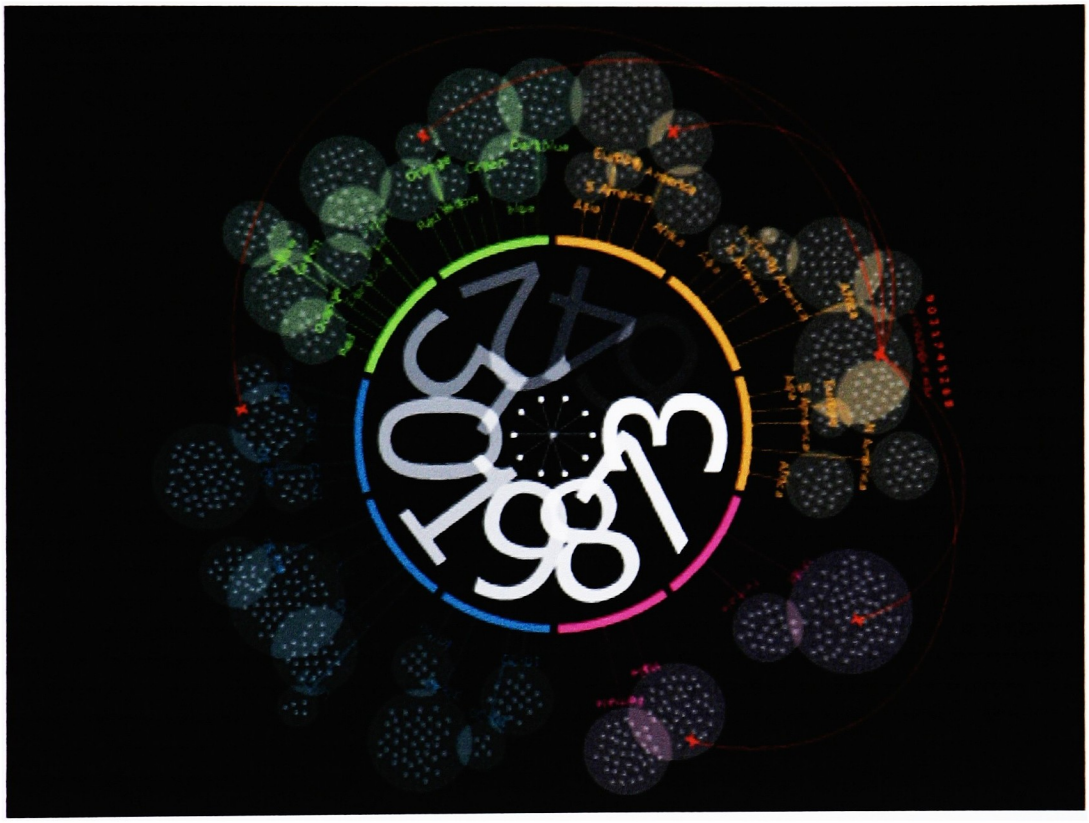
Timeline

This timeline shows the total amount of data. According to the time when user input the data, data is placed in the timeline. Constant numbers of data are shown in visualization at once. A user can drag this timeline to change the period of data shown in the stage.

3.2.3. Visual Design

The main visual concept is an exact circle and four color codes. According to the metaphor, trees on a planet, ten big numbers are put in a circle inside ten color

sections. And many circles containing a lot of dots are linked with the ten outside sections using a line as if various trees and their fruits have been planted on the ground of a planet. The color of circles containing dots, texts, and lines is the same color as the connected section. The size of circles is generated relative to the number of dots, which means that other people are included in one sub-section. There are visual options related with people, text, circle, line and percentage to change what the user wants to see.



3.2.1.Image of Prototype 02

3.2.4. Problems

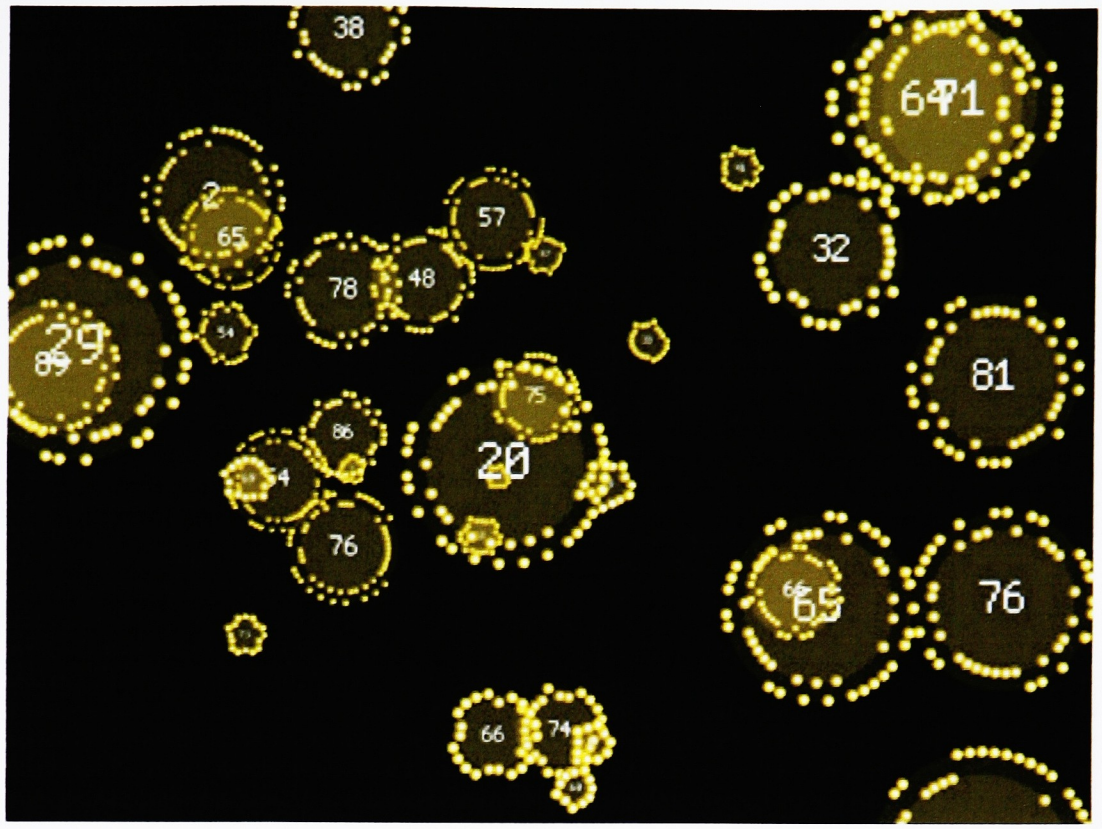
- The visualization is too complicated to understand.
- The interaction using the mouse wheel is difficult and limited to the mouse containing a wheel.
- There is not enough space to show the data of other people.
- The transition to the other person's information is not natural.

3.3. Prototype 02

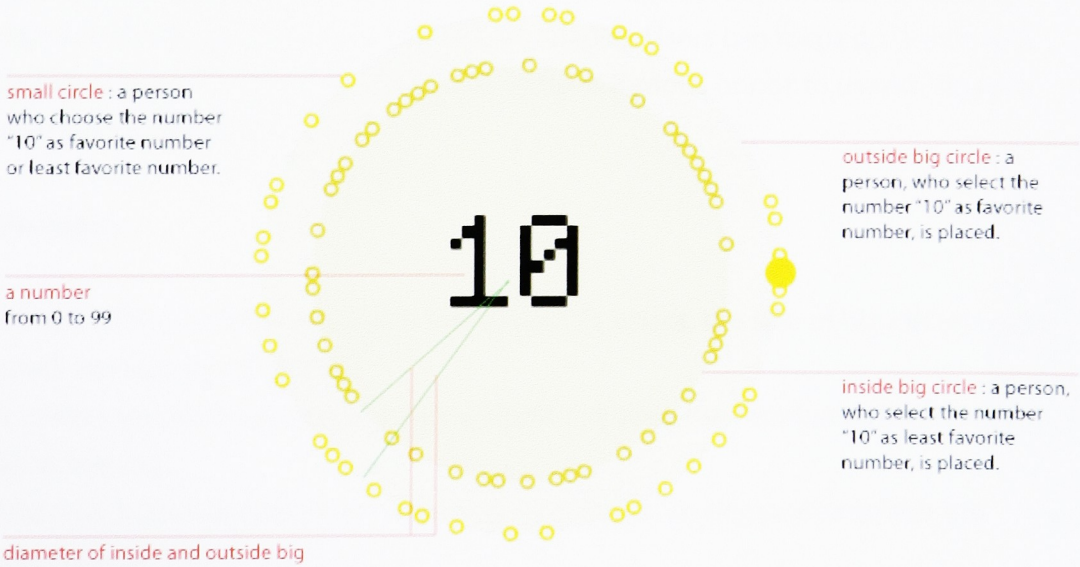
One day a new approach to the visualization suggested itself to me. I had struggled with the problem of visualizing the relationships between the preference order of ten numbers and other people's data with their background information. Each person has both ten different numbers in an order and other sub-information about their cultural contexts including continent, age, and gender; thus, all of this information from many people was so entangled that it was difficult to show their connections of the data. However, if I think more simply about the preference of numbers, I could find the solution to the visualization problem. I did not need to get the preference order of ten numbers from users. To show the preference of numbers more clearly, only two numbers, the favorite and least favorite numbers, are needed. From this new idea, the way of visualization was totally changed in a different direction. If I collect the data about the favorite and least favorite number, the range of numbers could be extended. Hence, I increased the boundary of numbers from ten to one hundred. Users can choose two favorite and least favorite numbers between 0 to 99 and the data of all numbers, which users select, is mapped interactively at the same time. In addition, I realized that the information about cultural contexts of users couldn't be visualized with the preferences of numbers in the same position of concentration. It can be divided into several sections, which have different strengths. As a result, I designed four visualization modes including numbers, continent, age and gender, and in each mode the data is visualized based on the mode.

3.3.1. Step 1

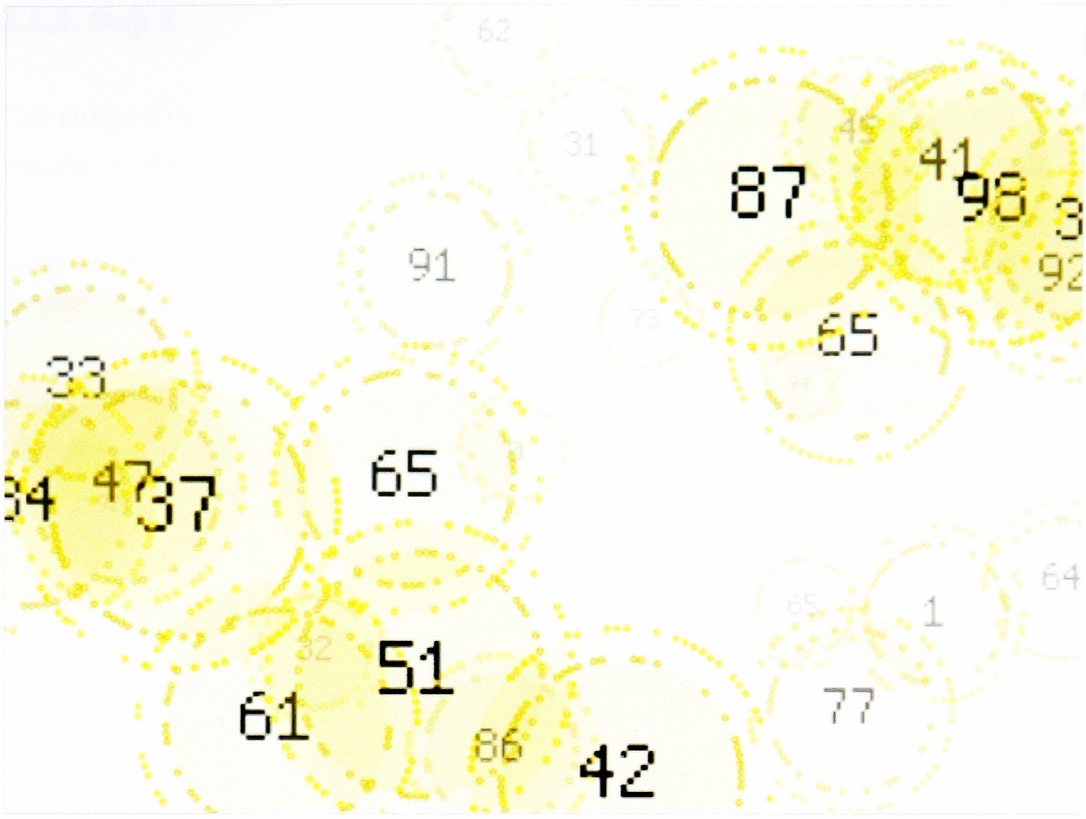
There are 100 numbers floating on the screen, and each number is surrounded by a varying numbers of small circles. The small circle represents one person who chooses the number enclosed by it as favorite number or least favorite number. The small circles are placed in a circle around the numbers, and the distance from a number to a small circle is determined by the person. Small circles put in outside circle line around a number are people who think of the number as a favorite; in contrast, small circles placed inside a circle line mean people who select the number as their least favorite. The size of small circles is fixed, so the diameter of big circles which small circles p is generated according to the number of small circles.



3.3.1.Prototype 03 Screenshot



3.3.2.Diagram of a number



3.3.3.Image of numbers placed in 3D space

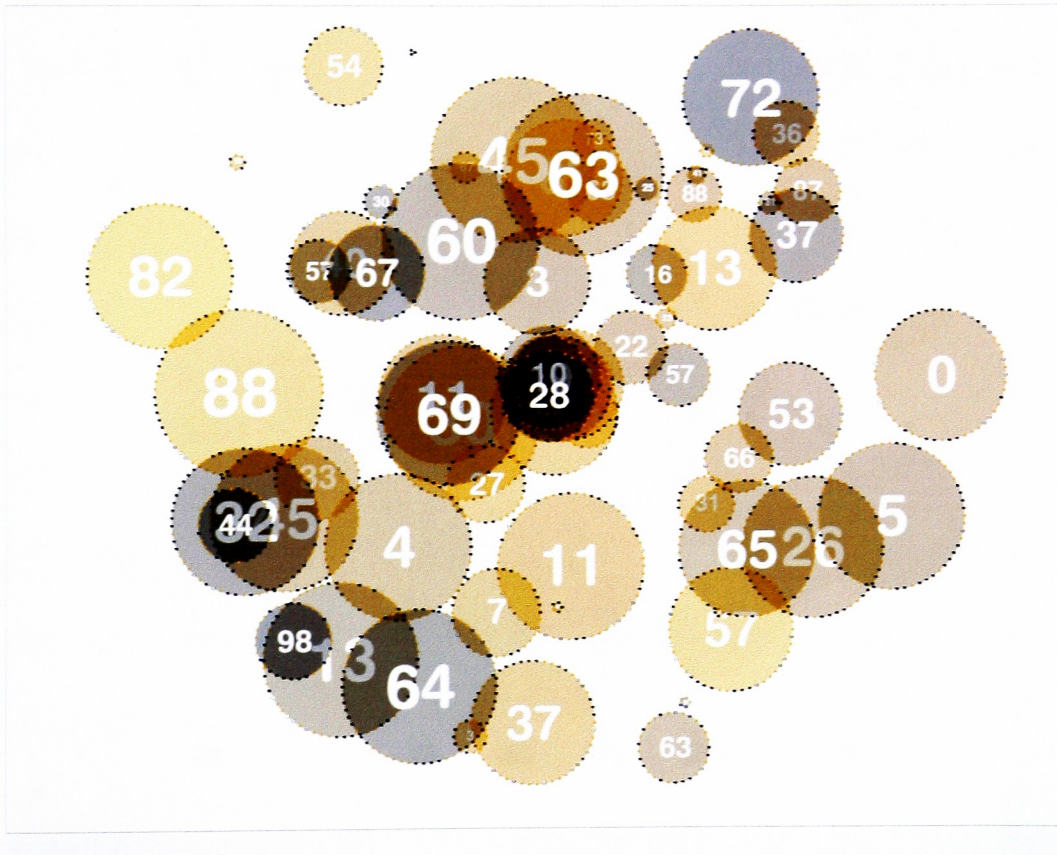
This is a picture of numbers placed in 3D space. Each number has different depth from the view in proportion to the number of small circles, and users can explore numbers as moving to X, Y, Z positions. As the depth of a number is farther, the size and the alpha value of a number are smaller. Users can focus on the closest number easily and recognize which number is famous or not to users thanks to the three dimensions.

Problems

- In case of the number small number of people select, the size of big circles is too small to show small circles.
- It is not easy to recognize how many people choose the number as favorite or least favorite.
- The connection between numbers is hard to visualize because numbers are placed in 3D space.
- Many numbers of big circles are overlapped, so it is hard to find the number the user want to know.

3.3.2. Step 2

The shape of small circles is changed a little bit and favorite and least favorite number is classified according to the color not the diameter of big circles. Small circles are placed in one big circle around a number and the size of big circles is generated according to the number of small circles. There are two colors of small circles: orange means a person thinks of the number as a favorite and black means a person selects the number as a least favorite. Also the color of the big circle is changed in proportion to the number of small orange and black circles; users can therefore recognize the preference of numbers at a glance.



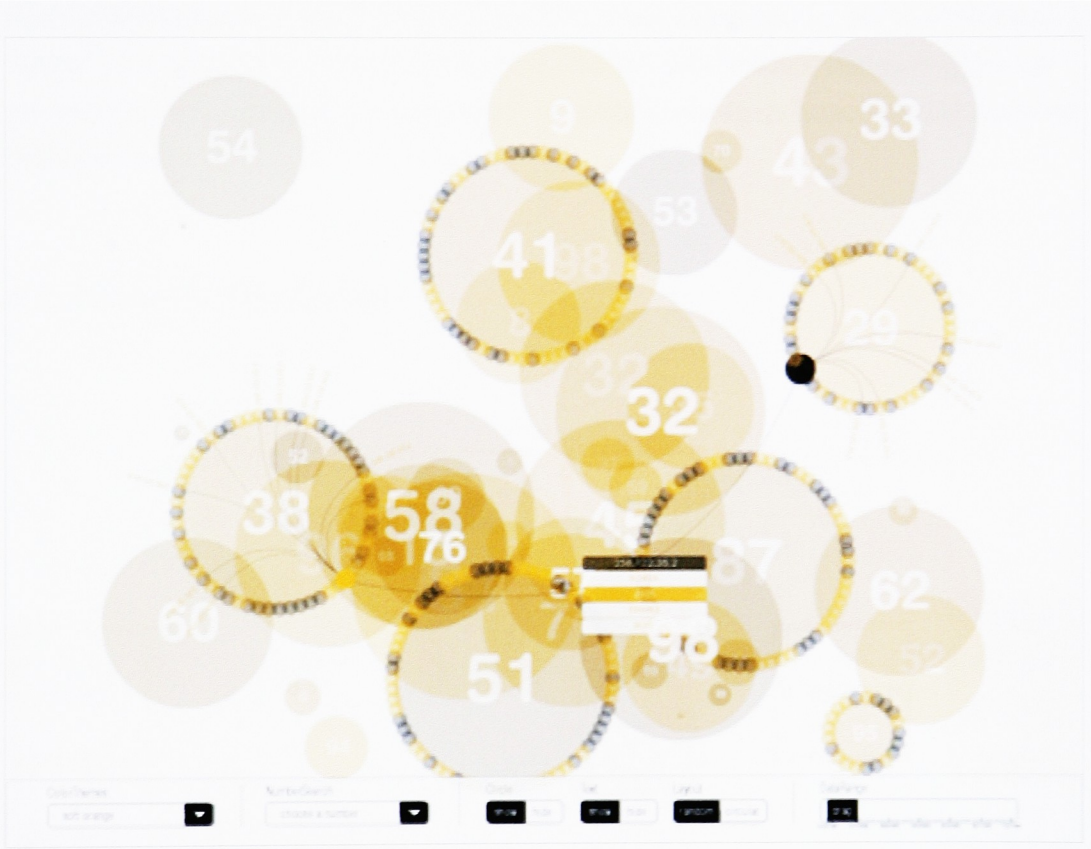
3.3.4.Image of the prototype, Step 2

Problems

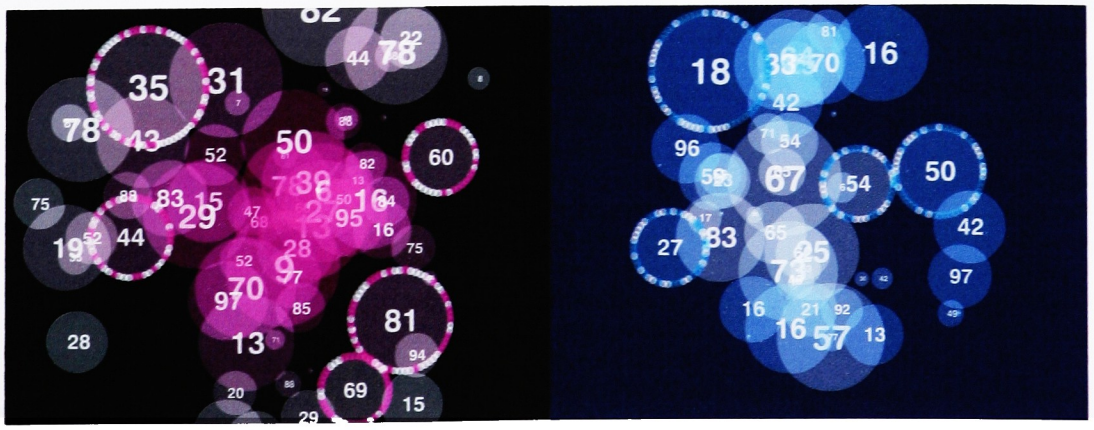
- Small circles are too small to recognize and to click using a mouse.
- But if the small circles are enlarged, it becomes more complicated because one hundred numbers are needed to show in one screen.
- Many numbers of big circles are overlapped, so it is hard to find the number the user want to know.

3.3.3. Step 3

The small circles are enlarged and all small circles are hidden as a default. Upon clicking a number, small circles appear alone the big circle. This interaction allows users to select information suitable for their interests, so unnecessary data does not prohibit users from understanding complicated information. I added new functions of visualization such as Search number and Color theme. The search menu has a function to find the number easily and quickly and the color theme is made for to entertain users in an aesthetic view.



3.3.5.Image of the prototype, Step 3

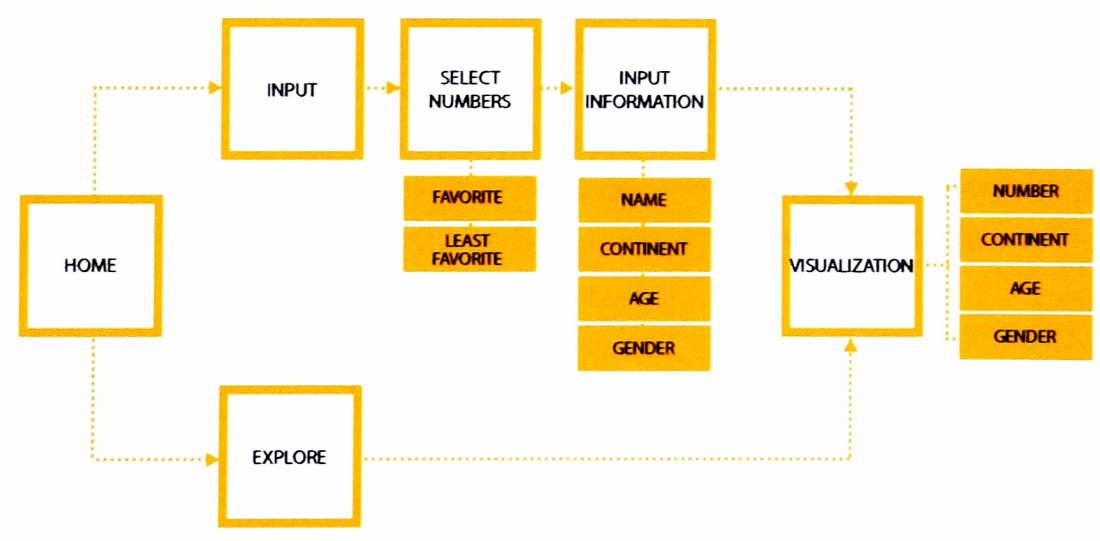


3.3.5.Images applied by different color themes

4. Final Application

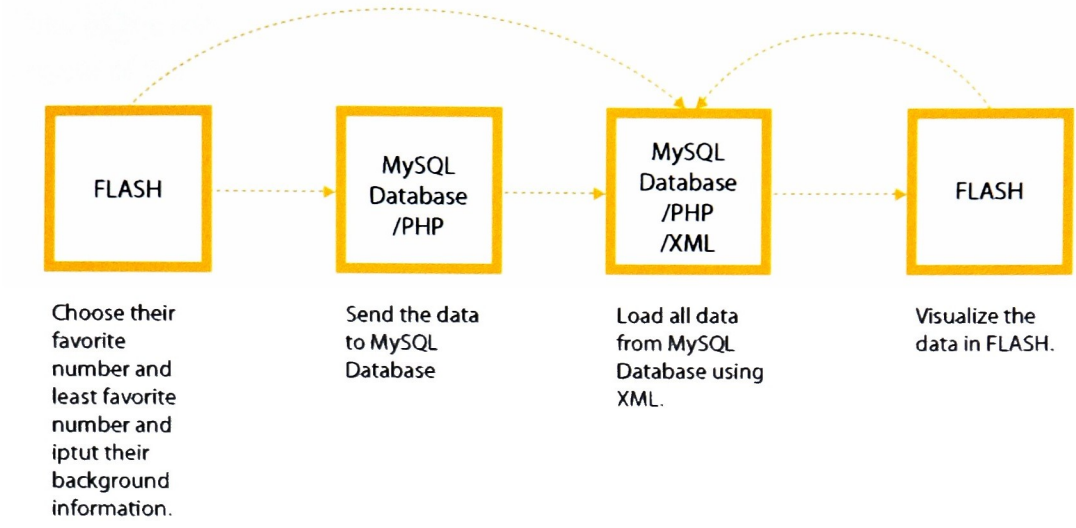
The final application follows the same idea of the prototype 03. While designing the last prototype, I realized that as the more people choose a number as a favorite one, the number itself becomes bigger and brighter. These features made me imagine blooming flowers under the sun. In contrast, the number of people with a bad impression is changed to dark color as if a flower in the shade fades. The interaction between numbers on the screen and users who input their data is exactly that between flowers and their surroundings. Thus, I decided to use the "blooming flower" as a metaphor of the visualization, and I finally finished designing the application for the interactive visualization in cultural contexts based on the number preferences.

4.1. Contents Hierarchy



The application is divided into two parts. One is the input part to collect the user's data and the other one is the exploration to visualize the data. In the input category, users select their favorite and least favorite numbers and then input their name, continent, age and gender. In the explore part, the data is visualized based on the same four elements.

4.2. Technical Process



The application provides the visualization according to the user's input in real time. To connect the MySQL Database with Macromedia Flash, the PHP platform is used. As the user input his or her data about the preference of numbers and background information, the data is sent to MySQL Database directly from the Macromedia Flash, and then all data stored in the server is loaded using the XML to the Macromedia Flash. In this process the visualization can interact with users' input in real time, so users can have a fun experience participating in the visualization using their data. Moreover, the visualization keeps changing according to the user's input, and the new result is produced continuously as time goes by.

4.3. Interaction Design

The number mode

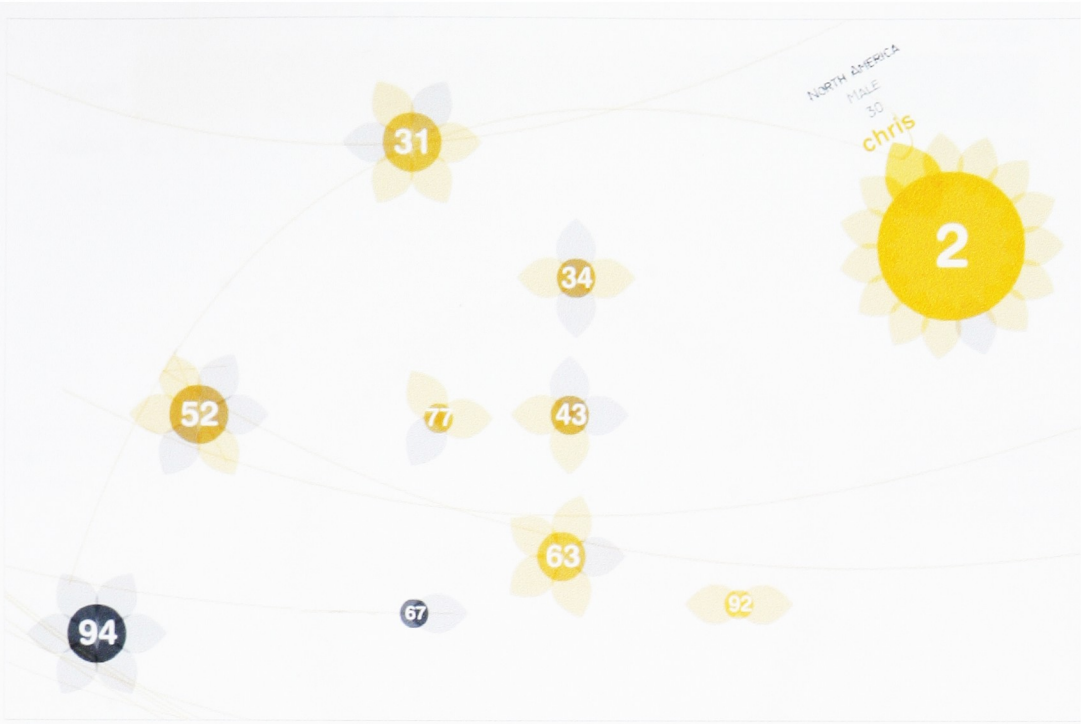
One hundred numbers of flowers from 0 to 99 are placed on the screen. Each flower has a different number of petals, size and color. In the center, a number is shown and the number's size also varies in proportion to the size of flower. One petal means one person has chosen the number inside the flower. There are two types of petals: the bright-color petal indicates the person who selects the inside number as a favorite; in contrast, the dark-color petal shows the person who selects the inside number as a least favorite. The color of the body of the flower is

mixed with orange and black, following the ratio of the number of orange to black petals. That is, the size of the flower represents the number of people who choose one number, as well as the color of the flower shows the preference for that number. As the user's mouse rolls over a petal, the size of petal is increases and the name of the person appears in the upper part of the petal.

4.3.1.Diagram of the flower in the number mode

4.3.2.Examples of flowers

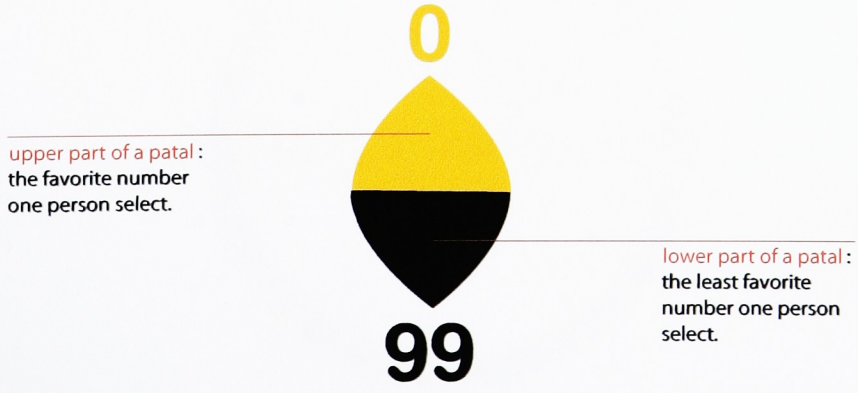
When clicking a petal, the user can see the person's name, continent, gender, and age. At the same time, two petals of the person are connected with one curve line because one person chooses two numbers as favorite and least favorite. The small window, which shows the information, can be deleted by the second clicking. When the center of a flower is clicked, all petals placed in the flower are connected with other petals at once. Also the selected one moves to the center of stage and the screen is zoomed out automatically to make users focus on the selected one.



4.3.3.Image of the petals connected with one curve line

The continent, gender, and age mode

In the other sections, the main concept of visualization is the same as with the number mode. However, some parts of the visualization should be changed because one person selects two numbers. That is why one petal is divided into two parts. The upper part of a petal represents the favorite number and the lower part represents the least favorite number. The color of a petal is generated according to the number. In an ascending order of numbers, the color is changed from the bright color to the dark color. When a mouse rolls over a petal, two numbers, the favorite number with the bright color and at least favorite number with the dark color, appear around the petal.



4.3.4.Diagram of the petal in the continent, gender, and age mode

4.3.5.Color chart according to the numbers

4.3.6.Diagram of the flower in the continent, gender, and age mode

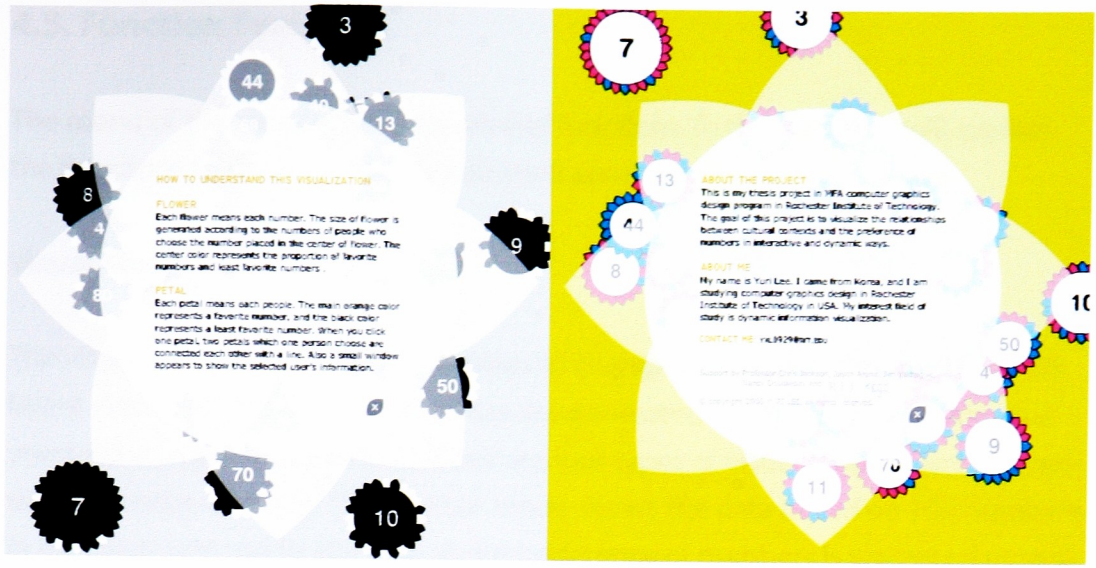
As a petal is clicked, the petal is connected with other petals, which have the same number as the favorite or least favorite number, using curved lines. The color of the lines is generated following the preference types. That is, petals connected with curved orange lines mean people who choose the same favorite number with the selected petal, and others linked with curved back lines represent people who select the same least favorite number.

4.3.6.Image of the flower as a petal is clicked

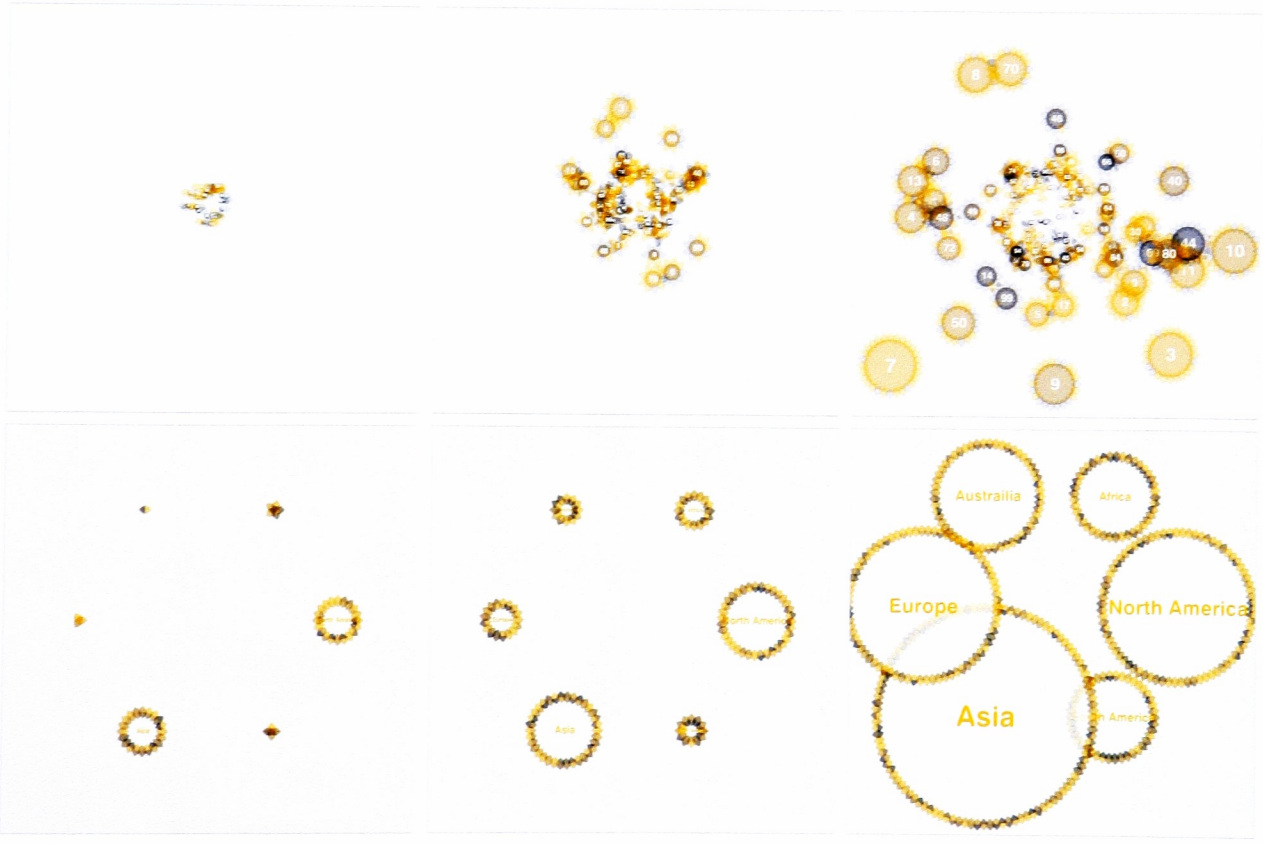
4.4. Visual Graphics

The main concept of visual design is clean, simple, and blooming flowers. This application handles a huge amount of information, so I tried to eliminate unnecessary design elements because additional parts can interfere with transmitting information to users. Fundamental objects are largely used, and only orange and gray colors are used in the entire application. The reason why orange is selected as a main color is that it connotes energy and brightness, and the significance of orange color is matched with the metaphor of blooming flowers. When designing other sections, I kept the consistency of the mood related to blooming flowers.

4.4.1.Index page(right top) 4.4.2.The page of selecting numbers(left top) 4.4.3.The page of inputting information (right bottom) 4.4.4.The visualization page(left bottom)



4.4.5.Hint window(left)
4.4.6.About window(right)



4.4.6.Image of loading data in the number mode(top) 4.4.7.Image of loading data in the continent mode(bottom)

4.5. Function Features

The menu of the visualization has several functions. In this section, I will explain the functions to optimize the visualization according to the user's desire.

Visual Mode

The visual mode provides opportunities to change the visualization based on different elements. Because these modes are generated using the information that users enter in the input section, there are four types of visual modes: number, continent, gender, and age. The number mode shows the data based on 100 numbers. In the continent mode; the data about preference of numbers is visualized according to the nationality of users, which is divided into six continents: North America, South America, Asia, Europe, Australia and Africa. The gender and the age modes also draw the visualization in the same way, and the gender section has two categories: male and female. The age section is composed of six levels: the teens, the twenties, the thirties, the forties, the fifties, and the sixties.

4.5.1.The number mode

4.5.2.The continent mode

4.5.3.The gender mode

4.5.4.The age mode

Customized Layout

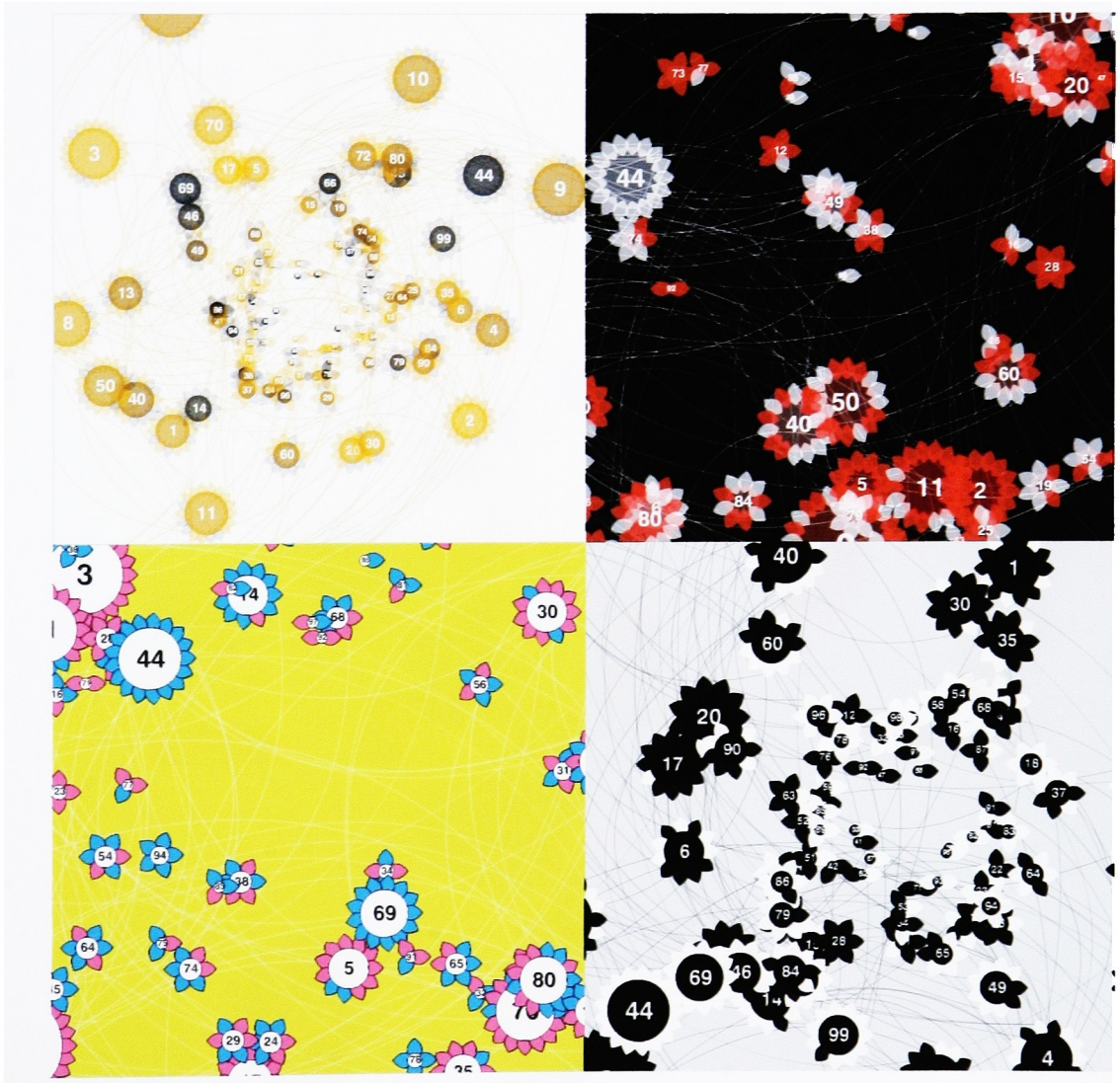
The customized layout is the changing the layout of flowers. There are three options for the layout: random, circular, and linear. The default is the circular layout, in which flowers are placed with the center of the stage. The distance from the center point is proportional to the size of flower, so big flowers move to the outside and small flowers are closer to the center. The second option is the random layout, which makes flowers move to a random position in the stage. And the other one, the linear layout, arranges flowers horizontally in ascending order. These layout options are especially useful for finding the specific number as many flowers overlap.

4.5.5.Random / circular / linear layout in the number mode

4.5.6.Random / circular / linear layout in the continent mode

Visual Option

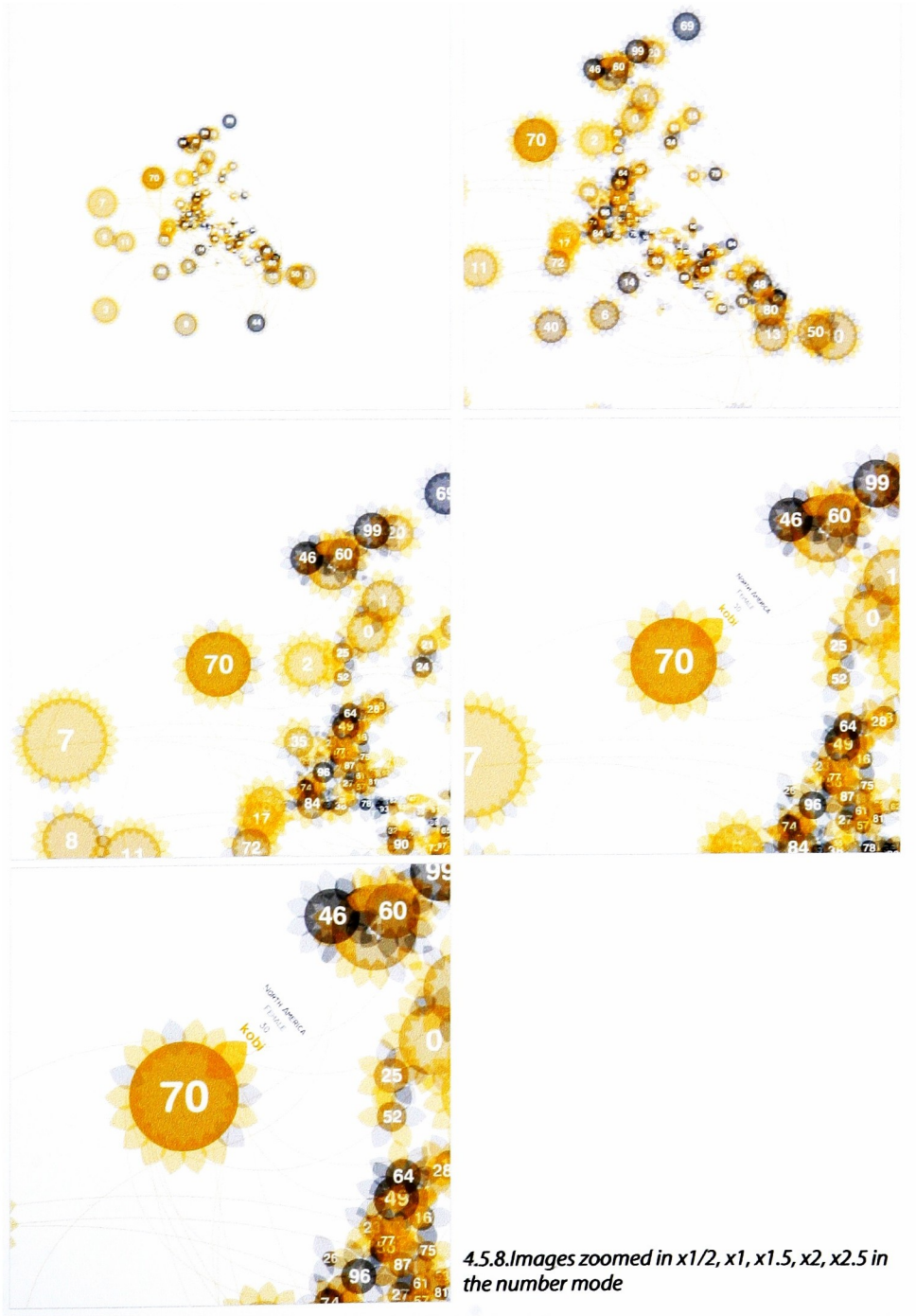
The visual option contains the color of visualization and the text option. Users can change the color of visualization to red, orange, black, and pink. Each color means the point color of the visualization and each color mode combines point color, the other side's color, and the background color. The other colors, not the point color, were picked by the harmony with the point color. By using the text option, users can easily turn the texts on flowers on and off. When texts are hidden on the screen, the scene of flowers connected with curve lines can be an artwork generated by programming.



4.5.7.Orange/ red/ pink/ black mode in the number mode (from left top to right bottom)

Zoom in/out

Using the zoom function, users can navigate in/out the screen. There are five steps: x1/2, x1, x1.5, x2, x2.5. When a petal is clicked, the screen is automatically zoomed in two times and when a flower is clicked, the screen is also zoomed in one-and-one-half times. Thus, to go back to the original size, users need to use the zoom function.



4.5.8.Images zoomed in x1/2, x1, x1.5, x2, x2.5 in the number mode

5. Summary

While developing my thesis application, I have incorporated feedback from my Thesis Committee as well as from students in computer graphics design. Based on the feedback, I have changed the idea of visualization from the first prototype to the final application. After finishing my thesis final application, I have tested the website with 15 people and received good feedback in regard to the interaction of flowers, the various options of visualization and the metaphor of blooming flowers. Most of them enjoyed experiencing the visualization, especially after they input their data. When they found the petals showing their data in a bunch of flowers, they were impressed with the visualization. However, some people had difficulty in finding the input mode. Also, some users complained about the speed of loading data. Because the Flash file contains a lot of movie clips in this project, it takes some time to load all information and change the properties of movie clips at the same time. In the future, I will fix the part of the link with the input mode to catch the user's eye more definitely and find a solution to decrease the speed of loading data.

6. Conclusion

The purpose of my thesis is to visualize the relationships between cultural contexts and the preference of numbers in interactive and dynamic ways. I designed an interactive application presented on a website in order to experiment with the preference of numbers and personal background information. While designing the final application, I made several guidelines to visualize a large quantity of information whose structures and contents are continuously changed.

- *Make levels for obtaining information*
  Not all information needs to be shown at once. Make the priority order of information, and make users get data from the most to the least important information.

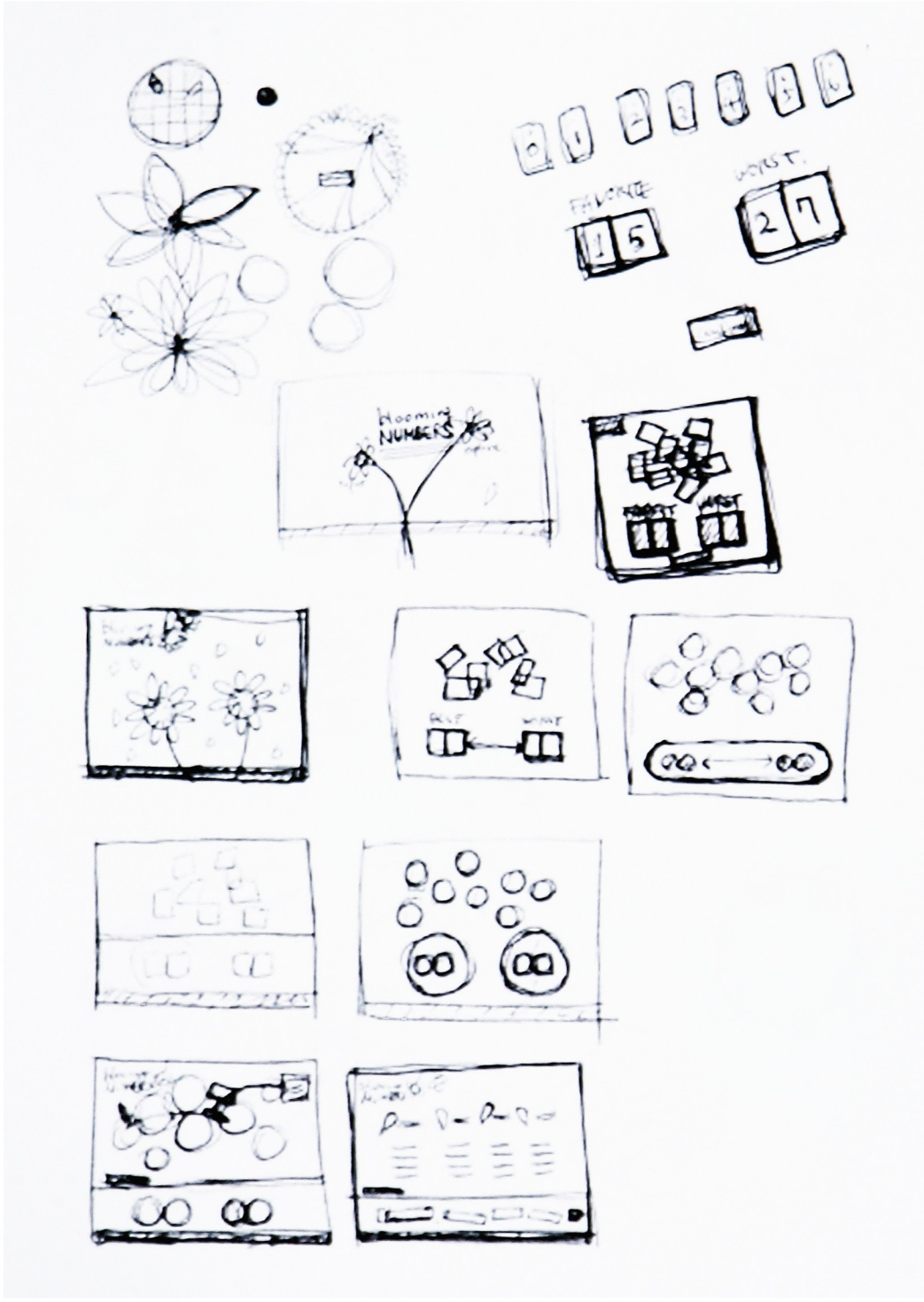
- *User-centered visualization*
  Provide users the possibilities of changing the setting of the visualization. Users can experience the visualization optimized to them, and have fun with changing the visualization.

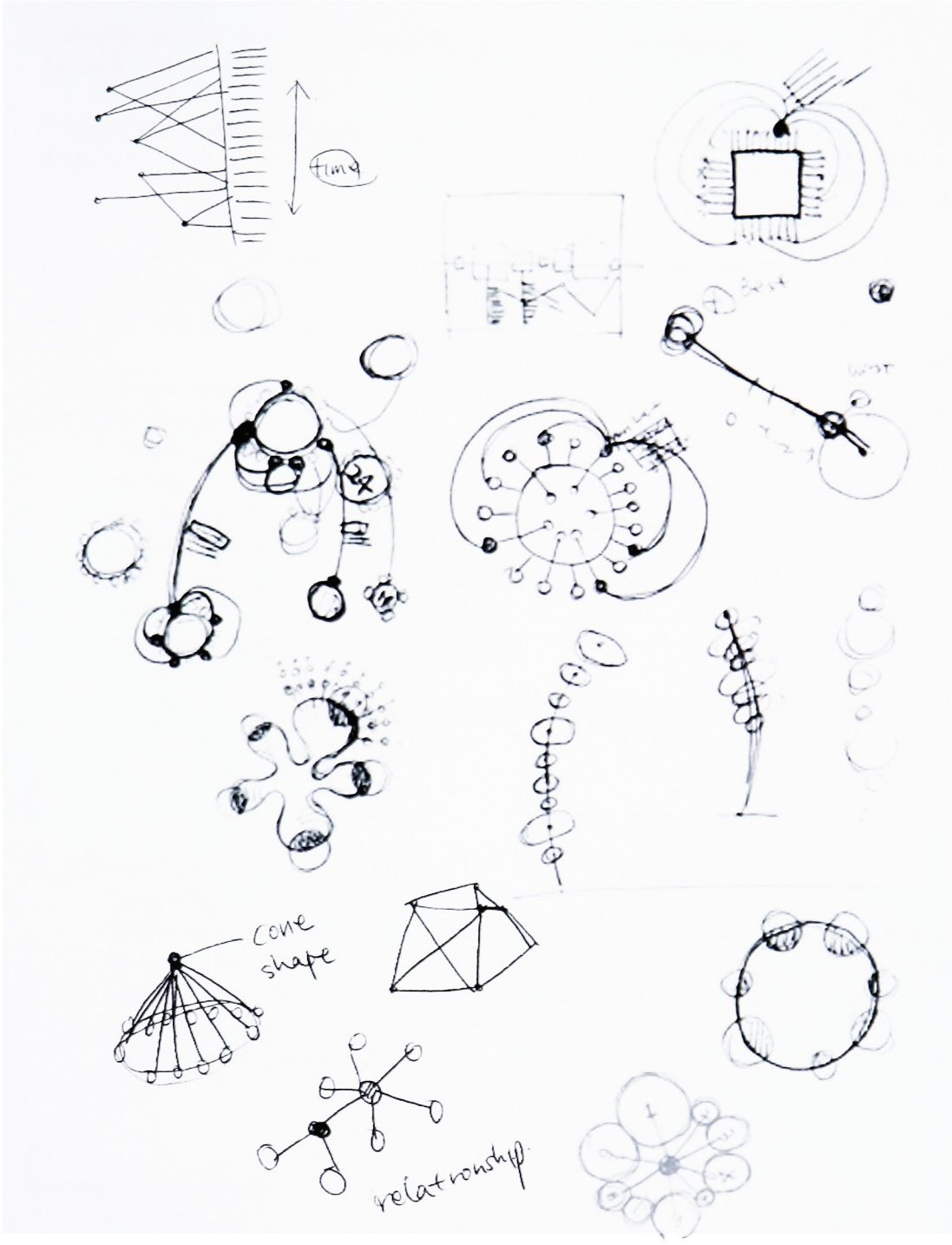
- *Eliminate unnecessary parts*
  Think of the information first. Keep the visual design clean because some decorative parts can interrupt understanding information. Provide convenience and enjoyment with using an interesting interaction design.

After finishing the application, I submitted the project to the Adobe Achievement Design Awards 2006. My project earned Honorable Mention in the interactive category. Even though the application still has room for improvement, I am truly satisfied with the result of my MFA thesis project. Based on this project, I would like to continue exploring the field of dynamic information design. The area of visualizing information in other devices such as mobiles or exterior installations, not limited to computers, is a potential area in which the study of dynamic information visualization can be applied.

7. Appendix

7.1. Idea Sketches




time
cone
shape
relationship

7.2. Coding Examples

7.2.1.Send/Load data in Macromedia Flash

```
// change gameID to your table assigned int he Highscore Database
gameID = "numtable";

// returnNum. adjust to change the amount scores returned to Flash.
returnNum = 1000;

// Base URL: data/highScoreGet.php is located in students/data.
// change the base URL to a relative path in relation to your game.swf
// Example: this SWF is in students/jason/highscore
baseUrl = "http://www.urielee.com/"

// sends and reieves new scores
makeObj = function(){
        sendScore = new LoadVars();
        sendScore.name= myName;
        sendScore.nation= myNation;
        sendScore.age= myAge;
        sendScore.gender= myGender;
        sendScore.bnum= myBestNumber;
        sendScore.wnum= myWorstNumber;
        sendScore.gameID = gameID;
        sendScore.sendAndLoad(baseUrl + "data/highScoreSend.php", sendScore,"POST");
        sendScore.onLoad =loadScores();
        //trace("makeObj Done");
}

function loadScores(){
        scoreXML = new XML();
        scoreXML.load(baseUrl + "data/highScoreGet.php?gameID="+gameID+"&return
        Num="+returnNum+"&userid="+userid+"&name="+name+"&nation="+nation+"
        &age="+age+"&gender="+gender+"&bnum="+bnum+"&wnum="+wnum);
        scoreXML.onLoad = showresults;
        //trace("loadScores Done");
}

//
function showresults(){
        hsInfo=[];
        hsInfo = scoreXML.firstChild.childNodes;
        //trace(hsInfo);
}
```

7.2.2. Connect to MySQL Database in PHP

```
<?php
// connect to server
if(!($dbLink = mysql_connect("localhost", "jason", "jason")))

{
        print("Failed to connect<br> \n");
        print("ABort<br>\n");
        exit();
}


// select DB
if(!($dbResult = mysql_query("USE numtable", $dbLink)))
{
        print("Cant use the test db <br>\n");
        print("Abort<br>\n");
        exit();
}
?>
```

7.2.3. Send data to MySQL Database in PHP

```
<?php
include 'config.php';
$un=$_POST["name"];
$n0=$_POST["bnum"];
$n1=$_POST["wnum"];
$na=$_POST["country"];
$ag=$_POST["age"];
$ge=$_POST["gender"];
$gameID=$_POST["gameID"];

$Query="INSERT INTO $gameID (name, bnum, wnum, country, age, gender) values('$un',
'$n0','$n1','$na','$ag','$ge')";

//4: Send Query to MySQL, Adds new entry to database
mysql_query($Query);

echo "$SuccessMsg";

?>
```

7.2.4. Load data from MySQL Database in PHP

```
<?php
include'config.php';
$gameIDe=$_GET["gameID"];
$returnNum=$_GET["returnNum"];
// connect to server

$Query = "SELECT id, name, bnum, wnum, country, age, gender " ."FROM " . $gameIDe ."
ORDER BY id DESC ";

if(!($dbResult = mysql_query($Query,$dbLink)))
{
        print("Could not exacute query<br>\n");
        exit();
}

echo'<?xml version="1.0" ?>';
echo'<scores>';

                while($dbRow = mysql_fetch_assoc($dbResult))
                        {
                                if($i<=$returnNum){
                                        echo'<score id="" .$dbRow[id]."" name="".
$dbRow[name]."" bnum="" .$dbRow[bnum]."" wnum="" .$dbRow[wnum]."" country=""
.$dbRow[country]."" age="". $dbRow[age]."" gender="". $dbRow[gender]."" />';
                                        $i++;
                                }
                        }

echo'</scores>';
?>
```

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Art from code-Generator.x *http://www.generatorx.no/*

Ben Fry *http://www.benfry.com/*

Dentsu Online *http://www.dentsu.com/*

GroupC/Casey REAS *http://www.groupc.net/*

Joshua Davis *http://www.joshuadavis.com/*

Levitated/the Exploration of Computation *http://www.levitated.net/*

Liquid Journey *http://www.liquidjourney.com/*

Marius Watz/Unlekker.net *http://www.unlekker.net/index.php*

Moock.org *http://www.moock.org/*

Processing *http://processing.org/*

Sodaplay *http://www.sodaplay.com/*

They Rule *http://www.theyrule.net/*

Yugop.com *http://www.yugop.com/*

VisualComplexity.com *http://www.visualcomplexity.com/*


Blooming Numbers
CD-R
700MB
80min.
MFA Thesis — Yuri Lee